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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2016/2017

EME1026 – FLUID MECHANICS
(ME)

12 OCTOBER 2016
9:00 a.m. – 12:00 p.m.
(2 hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of EIGHT pages including cover page.
2. There are FOUR questions in total.
3. Attempt **ALL** questions. All questions carry equal marks. In each question, Part A is compulsory and answer either Part B or Part C.
4. Please write all your answers in the Answer Booklet provided.

Question 1

Figure Q1a shows a nozzle in horizontal position. Water (density 1000 kg/m^3) flows from the inlet to the outlet which is at atmospheric condition.

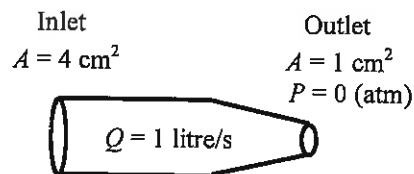


Figure Q1a

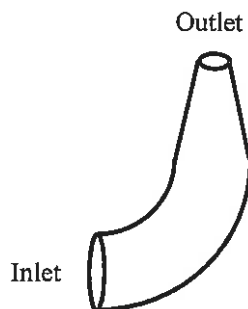


Figure Q1b

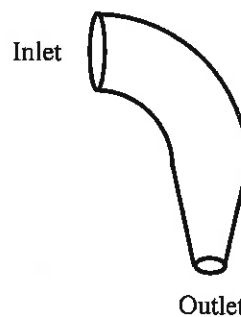


Figure Q1c

PART A (compulsory, 15 marks)

(i) Sketch Figure Q1a, draw and label one streamline from the inlet to the outlet of the nozzle. After that, find the pressure at the inlet of the nozzle. **[6 marks]**

(ii) Sketch a control volume showing all the forces required to analyse the anchoring force required to hold the nozzle in its position. After that, find the anchoring force. The weight of both the water and the nozzle can be neglected when analysing. **[5 marks]**

(iii) Use sketches to describe briefly how the anchoring force is applied to the nozzle in actual practice. Also, describe briefly what happens to the nozzle if the anchoring force is not applied. **[4 marks]**

Continued...

Question 1 (continued)**PART B (optional, answer either part B or part C, 10 marks)**

The nozzle is turned to point upward as shown in Figure Q1b. The inlet and outlet conditions are assumed the same as in Figure Q1a. However, the anchoring force is now expected to be different.

Sketch a control volume showing all the forces required to analyse the anchoring force required to hold the nozzle in its position. After that, find the magnitude and direction of the anchoring force. Sketches can be used to state the direction of the anchoring force. The weight of both the water and the nozzle can be neglected when analysing.

[10 marks]

PART C (optional, answer either part B or part C, 10 marks)

The nozzle is turned to point downward as shown in Figure Q1c. The inlet and outlet conditions are assumed the same as in Figure Q1a. However, the anchoring force is now expected to be different.

Sketch a control volume showing all the forces required to analyse the anchoring force required to hold the nozzle in its position. After that, find the magnitude and direction of the anchoring force. Sketches can be used to state the direction of the anchoring force. The weight of both the water and the nozzle can be neglected when analysing.

[10 marks]

Continued...

Question 2**PART A (compulsory, 15 marks)**

Water flows through a horizontal smooth pipe with a diameter of 0.2 m at a velocity of 10 cm/s. Determine the pressure drop per meter of pipe using Moody chart. The dynamic viscosity of water is $1.12 \times 10^{-3} \text{ N.s/m}^2$. **[15 marks]**

PART B (optional, answer either part B or part C, 10 marks)

For Problem Q2 Part A, calculate the power lost to the friction per meter of pipe. **[10 marks]**

PART C (optional, answer either part B or part C, 10 marks)

Water flows through a horizontal 60 mm diameter galvanized iron pipe at a rate of $0.02 \text{ m}^3/\text{s}$. If the pressure drop is 135 kPa per 10 m of pipe, do you think that this pipe is:

- (i) A new pipe,
- (ii) An old pipe with a somewhat increased roughness due to aging, or
- (iii) A very old pipe that is partially clogged by deposits?

Justify your answer with detail calculations. **[10 marks]**

Continued...

Question 3**PART A (compulsory, 15 marks)**

Lift force F_L on an airplane wing is found to be dependent on flow speed V , chord length of the wing ℓ , density ρ , viscosity μ and the angle of the attack θ .

(i) List out all the variables in this question and the dimension associated with each of them. **[3 marks]**

(ii) How many pi groups can be constructed? Justify your answer. **[3 marks]**

(iii) Construct all the pi groups and thus, write down the final functional relationship. **[9 marks]**

PART B (optional, answer either part B or part C, 10 marks)

A prototype gate valve which controls the flow in a pipe system conveying paraffin is to be studied in a model. All the pi groups are given as below. A 1/5 scale model is built to determine the pressure drop across the valve with water as the working medium. Note: The density and viscosity of paraffin are 800 kg/m^3 and 0.002 kg/m.s respectively. Take the kinematic viscosity of water as $1.0 \times 10^{-6} \text{ m}^2/\text{s}$.

$$\pi_1 = \frac{\Delta p}{\rho V^2}, \pi_2 = \frac{h}{D}, \pi_3 = \frac{\mu}{\rho V D}$$

Δp = pressure drop, h = gate opening, d = overall depth, ρ = density, μ = viscosity and V = Velocity

(i) For a particular opening, when the velocity of the paraffin in the prototype is 3.0 m/s , what should be the velocity of water in the model for dynamic similarity. **[5 marks]**

(ii) What is the ratio of the quantities of flow in the prototype and model? **[5 marks]**

PART C (optional, answer either part B or part C, 10 marks)

(i) Based upon the diameter and average velocity for axial flow through a circular tube, the Reynolds number for transition to turbulence is approximately 2300. Diameter of the tube is 5 cm . Taking the density and fluid viscosity for kerosene at 20°C are 804 kg/m^3 and 0.00192 kg/m.s respectively, determine the volume flow rate in m^3/h which causes the transition. **[6 marks]**

(ii) Determine the dimension of viscosity using the relation: $\tau = \mu(dU/dy)$ where U is the velocity, y is the length, τ is the shear stress and μ the viscosity. **[4 marks]**

Continued...

Question 4**PART A (compulsory, 15 marks)**

A centrifugal water pump having an impeller diameter of 0.5 m operates at 900 rpm. The water enters the pump parallel to the pump shaft. The exit blade angle, β_2 is 25° . The uniform blade height is 50 mm.

(i) Sketch the velocity triangle for the impeller exit flow and indicate exit blade angle, β_2 . **[5 marks]**

(ii) Determine the shaft power required to turn the impeller when the flow through the pump is $0.16 \text{ m}^3/\text{s}$. **[10 marks]**

PART B (optional, answer either part B or part C, 10 marks)

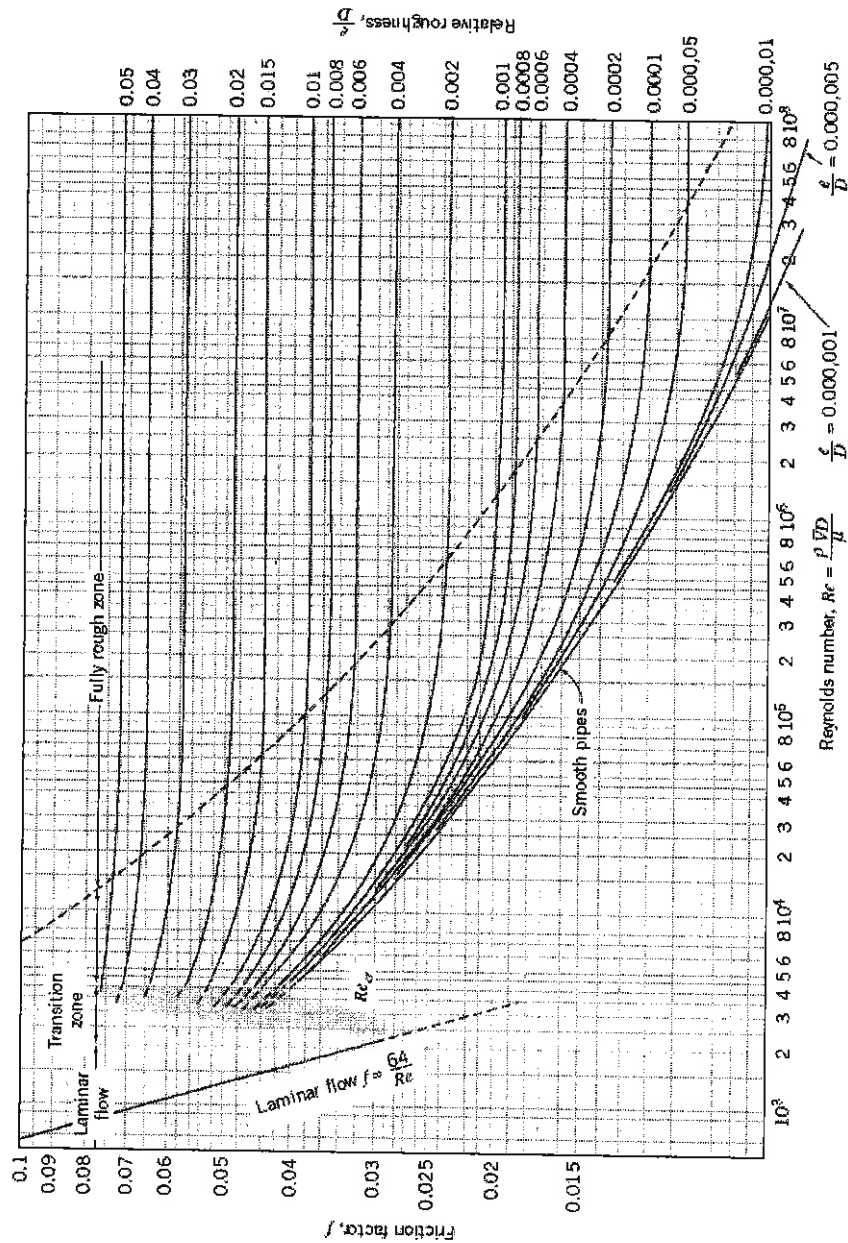
Water at 40°C is pumped from an open tank through 200 m of 50 mm diameter smooth horizontal pipe and discharge into the atmosphere with a velocity of 3 m/s. Minor losses are negligible. If the efficiency of the pump is 70%, how much power is being supplied to the pump? **[10 marks]**

PART C (optional, answer either part B or part C, 10 marks)

An open tank filled with water at 40°C flow through 200 m of 50 mm diameter smooth horizontal pipe and discharge into atmosphere at 3 m/s velocity. What is the NPSH_A at the pump inlet? Neglect losses in the short section of pipe connecting the pump to the tank. Assume standard at atmospheric pressure and minor losses are negligible. **[10 marks]**

End of paper

APPENDIX 1: Friction factor for fully developed flow in circular pipes



APPENDIX 2: Physical Properties of Water

Temperature (°C)	Density, ρ (kg/m ³)	Specific Weight ^b , γ (kN/m ³)	Dynamic Viscosity, μ (N·s/m ²)	Kinematic Viscosity, ν (m ² /s)	Surface Tension ^c , σ (N/m)	Vapor Pressure, p_v [N/m ² (abs)]	Speed of Sound ^d , c (m/s)
0	999.9	9.806	1.787 E - 3	1.787 E - 6	7.56 E - 2	6.105 E + 2	1403
5	1000.0	9.807	1.519 E - 3	1.519 E - 6	7.49 E - 2	8.722 E + 2	1427
10	999.7	9.804	1.307 E - 3	1.307 E - 6	7.42 E - 2	1.228 E + 3	1447
20	998.2	9.789	1.002 E - 3	1.004 E - 6	7.28 E - 2	2.338 E + 3	1481
30	995.7	9.765	7.975 E - 4	8.009 E - 7	7.12 E - 2	4.243 E + 3	1507
40	992.2	9.731	6.529 E - 4	6.580 E - 7	6.96 E - 2	7.376 E + 3	1526
50	988.1	9.690	5.468 E - 4	5.534 E - 7	6.79 E - 2	1.233 E + 4	1541
60	983.2	9.642	4.665 E - 4	4.745 E - 7	6.62 E - 2	1.992 E + 4	1552
70	977.8	9.589	4.042 E - 4	4.134 E - 7	6.44 E - 2	3.116 E + 4	1555
80	971.8	9.530	3.547 E - 4	3.650 E - 7	6.26 E - 2	4.734 E + 4	1555
90	965.3	9.467	3.147 E - 4	3.260 E - 7	6.08 E - 2	7.010 E + 4	1550
100	958.4	9.399	2.813 E - 4	2.940 E - 7	5.89 E - 2	1.013 E + 5	1543

^aBased on data from: *Handbook of Chemistry and Physics*, 69th Ed., CRC Press, 1988.

^bDensity and specific weight are related through the equation $\gamma = \rho g$. For this table, $g = 9.807 \text{ m/s}^2$.

^cIn contact with air.

^dFrom R. D. Blevins, *Applied Fluid Dynamics Handbook*, Van Nostrand Reinhold Co., Inc., New York, 1984.

APPENDIX 3: Equivalent roughness in circular pipe

Pipe	Equivalent Roughness, ϵ	
	Feet	Millimeters
Riveted steel	0.003–0.03	0.9–9.0
Concrete	0.001–0.01	0.3–3.0
Wood stave	0.0006–0.003	0.18–0.9
Cast iron	0.00085	0.26
Galvanized iron	0.0005	0.15
Commercial steel or wrought iron	0.00015	0.045
Drawn tubing	0.000005	0.0015
Plastic, glass	0.0 (smooth)	0.0 (smooth)